Polyethylene glycol

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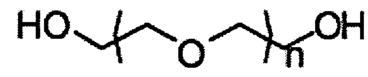	
IUPAC name	[show]
Identifiers	
CAS number	25322-68-3
Properties	
Molecular formula	$C_{2n+2}H_{4n+6}O_{n+2}$
Molar mass	44n+62
Hazards	
Flash point	182 - 287 °C
Except where noted otherwise, data are given for materials in their standard state (at 25 °C, 100 kPa) Infobox references	

Poly(ethylene glycol) (PEG), also known as **poly(ethylene oxide)** (PEO) or polyoxyethylene (POE), is the most commercially important type of polyether. PEG, PEO or POE refers to an oligomer or polymer of ethylene oxide. The three names are chemically synonymous, but historically PEG has tended to refer to oligomers and polymers with a molecular mass below 20,000 g/mol, PEO to polymers with a molecular mass above 20,000 g/mol, and POE to a polymer of any molecular mass.[2] PEG and PEO are liquids or low-melting solids, depending on their molecular weights. PEGs are prepared by polymerization of ethylene oxide and are commercially available over a wide range of molecular weights from 300 g/mol to 10,000,000 g/mol. While PEG and PEO with different molecular weights find use in different applications and have different physical properties (e.g. viscosity) due to chain length effects, their chemical properties are nearly identical. Different forms of PEG are also available dependent on the initiator used for the polymerization process. The most common of which is a monofunctional methyl ether PEG (methoxypoly(ethylene glycol)), abbreviated mPEG. PEGs are also available with different geometries. *Branched* PEGs have 3 to 10 PEG chains emanating from a central core group. *Star* PEGs have 10 - 100 PEG chains emanating from a central core group. *Comb* PEGs have multiple PEG chains normally grafted to a polymer backbone.

Their melting points vary depending on the Formula Weight of the polymer. PEG or PEO has the following structure:

$$HO\text{-}CH_2\text{-}(CH_2\text{-}O\text{-}CH_2\text{-})_n\text{-}CH_2\text{-}OH$$

The numbers that are often included in the names of PEGs indicate their average molecular weights, e.g. a PEG with n=9 would have an average molecular weight of approximately 400 daltons and would be labeled PEG 400. Most PEGs include molecules with a distribution of molecular weights, i.e. they are polydisperse. The size distribution can be characterized statistically by its weight average molecular weight (Mw) and its number average molecular weight (Mn), the ratio of which is called the polydispersity index (Mw/Mn). Mw and Mn can be measured by mass spectrometry.

PEGylation is the act of covalently coupling a PEG structure to another larger molecule, for example, a therapeutic protein (which is then referred to as **PEGylated**). PEGylated interferon alfa-2a or -2b is a commonly used injectable treatment for Hepatitis C infection.

PEG is soluble in water, methanol, benzene, dichloromethane and is insoluble in diethyl ether and hexane. It is coupled to hydrophobic molecules to produce non-ionic surfactants.

Contents

Production

Poly (ethylene glycol) is produced by the interaction of ethylene oxide with water, ethylene glycol or ethylene glycol oligomers.[3] The reaction is catalyzed by acidic or basic catalysts. Ethylene glycol and its oligomers are preferable as a starting material instead of water, because it allows the creation of polymers with a low polydispersity (narrow molecular weight distribution). Polymer chain length depends on the ratio of reactants.

$$HOCH_2CH_2OH + n(CH_2CH_2O) \rightarrow HO(CH_2CH_2O)_{n+1}H$$

Depending on the catalyst type, the mechanism of polymerization can be cationic or anionic. The anionic mechanism is preferable because it allows one to obtain PEG with a low polydispersity. Polymerization of ethylene oxide is an exothermic process. Overheating or contaminating ethylene oxide with catalysts such as alkalis or metal oxides can lead to runaway polymerization which can end with an explosion after few hours.

Polyethylene oxide or high-molecular polyethylene glycol is synthesized by suspension polymerization. It is necessary to hold the growing polymer chain in solution in the course of the polycondensation process. The reaction is catalyzed by magnesium-, aluminium- or calcium-organoelement compounds. To prevent coagulation of polymer chains from solution, chelating additives such as dimethylglyoxime are used.

Alkali catalysts such as sodium hydroxide NaOH, potassium hydroxide KOH or sodium carbonate Na_2CO_3 are used to prepare low-molecular polyethylene glycol.

Clinical uses

Polyethylene glycol has a low toxicity[4] and is used in a variety of products. It is the basis of a number of laxatives (e.g. macrogol-containing products such as Movicol and polyethylene glycol 3350, or MiraLax or GlycoLax). It is the basis of many skin creams, as *cetomacrogol*, and sexual lubricants, frequently combined with glycerin. Whole bowel irrigation (polyethylene glycol with added electrolytes) is used for bowel preparation before surgery or colonoscopy and drug overdoses. It is sold under the brand names **GoLYTELY**, **GlycoLax**, **Fortrans**, **TriLyte**, **Colyte**, **Halflytely**, and **MoviPrep**. When attached to various protein medications, polyethylene glycol allows a slowed clearance of the carried protein from the blood. This makes for a longer acting medicinal effect and reduces toxicity, and it allows longer dosing intervals. Examples include PEG-interferon alpha, which is used to treat hepatitis C, and PEG-filgrastim (Neulasta), which is used to treat neutropenia. It has been shown that polyethylene glycol can improve healing of spinal injuries in dogs.[5] One of the earlier

findings that polyethylene glycol can aid in nerve repair came from the University of Texas (Krause and Bittner).[6] Polyethylene glycol is commonly used to fuse B-cells with myeloma cells in monoclonal antibody production. PEG has recently been proved to give better results in constipation patients than tegaserod.[7]

Research for New Clinical Uses

- High-molecular weight PEG, e.g., PEG 8000, is a strikingly potent dietary preventive agent against colorectal cancer in animal models.[8]

The Chemoprevention Database shows it is the most effective agent to suppress chemical carcinogenesis in rats. Cancer prevention in humans has not yet been tested in clinical trials.

- The injection of PEG 2000 into the bloodstream of guinea pigs after spinal cord injury leads to rapid recovery through molecular repair of nerve membranes.[9] The effect of this treatment to prevent paraplegia in humans after an accident is not known yet.
- Research is being done in the use of PEG to mask antigens on red blood cells. Various research institutes have reported that using PEG can mask antigens without damaging the functions and shape of the cell.

PEG is being used in the repair of motor neurons damaged in crush or laceration incidence in vivo and in vitro. When coupled with melatonin, 75% of damaged sciatic nerves were rendered viable.[10]

Other uses

PEG is used in a number of toothpastes as a dispersant; it binds water and helps keep gum uniform throughout the toothpaste. It is also under investigation for use in body armor[11] and tattoos to monitor diabetes.[12]

PEG is a popular precipitant for protein crystallization, X-ray diffraction of protein crystals can reveal the atomic structure of proteins.

Polymer segments derived from PEG polyols impart flexibility to polyurethanes for applications such as elastomeric fibers (spandex) and foam cushions.

Since PEG is a flexible, water-soluble polymer, it can be used to create very high osmotic pressures (tens of atmospheres). It also is unlikely to have specific interactions with biological chemicals. These properties make PEG one of the most useful molecules for applying osmotic pressure in biochemistry experiments, particularly when using the osmotic stress technique.

PEO (poly (ethylene oxide)) can serve as the separator and electrolyte solvent in lithium polymer cells. Its low diffusivity often requires high temperatures of operation, but its high viscosity even near its melting point allows very thin electrolyte layers. While crystallization of the polymer can degrade performance, many of the salts used to carry charge can also serve as a kinetic barrier to the formation of crystals. Such batteries carry greater energy for their weight than other lithium ion battery technologies.

When working with phenol in a laboratory situation, PEG 300 can be used on phenol skin burns to deactivate any residual phenol.

Poly (ethylene glycol) is also commonly used as a polar stationary phase for gas chromatography, as well as a heat transfer fluid in electronic testers.

PEG is also one of the main ingredients in Paintball fill since it's thick and flexible.

PEG has also been used to preserve objects which have been salvaged from underwater, as was the case with the warship Vasa in Stockholm.[13] It replaces water in wooden objects, which makes the wood dimensionally stable and prevents warping or shrinking of the wood.

PEG is often seen (as an internal calibration compound) in mass spectrometry experiments, with a characteristic fragmentation pattern.

In the field of microbiology, PEG precipitation is used to concentrate viruses and PEG is also used to induce complete fusion (mixing of both inner and outer leaflets) in liposomes reconstituted *in vitro*.

PEG is also used in lubricant eye drops. PEG derivatives such as narrow range ethoxylates are used as surfactants.

Dimethyl ethers of PEG are the key ingredient of Selexol, a solvent used by coal-burning, integrated gasification combined cycle (IGCC) power plants to remove carbon dioxide and hydrogen sulfide from the gas waste stream.

PEG has been used as the hydrophilic block of amphiphilic block copolymers used to create some polymersomes[14].

Gene therapy vectors (such as viruses) can be PEG-coated to shield them from inactivation by the immune system and to de-target them from organs where they may build up and have a toxic effect.[15] The size of the PEG polymer has been shown to be important, with large polymers achieving the best immune protection.

PEG is used as an excipient in pharmaceutical products. Lower molecular weight variants are used as solvents in oral liquids and soft capsules whereas solid variants are used as ointment bases, tablet bindings, film coatings and lubricants.[16]

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- polyethylene glycol - chemical product info: properties, production, applications.

See also

- PEGylation

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